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Technical Information

Steering

OSPE Steering Valve SASA Sensor

powersolutions.danfoss.com

Revision history

Table of revisions

Date	Changed	Rev
May 2015	Dimension drawing updated	DB
July 2014	Changed to Danfoss layout	DA
July 2011	Flow characteristics added	CA
October 2009	Major change	BA
August 2009	First edition	AA

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A wide range of Steering Components

Danfoss is one of the largest producers in the world of steering components for hydrostatic steering systems on off-road vehicles. Danfoss offers steering solutions both at component and system levels. Our product range makes it possible to cover applications of all types - ranging from ordinary 2-wheel steering (also known as Ackermann steering) to articulated steering, automatic steering (e.g. by sensor) and remote controlled steering via satellite. We can offer more than 1,800 different steering units and 250 different priority valves categorized in types, variants and sizes.

For hydrostatic steering systems Danfoss offers:

- Mini steering units with displacements from 32 to 100 cm^3/rev [1.95 to 6.10 in^3/rev], flow up to 20 l/min [5.28 US gal/min], steering pressure up to 140 bar [2030 psi].
- Steering units with displacements from 40 to 1200 cm^3/rev [2.44 to 73.2 in^3/rev], flow up to 100 l/min [26.4 US gaL/min, steering pressure up to 240 bar [3481 psi].
- Priority valves for rated flows at 40, 80, 120, 160 and 320 l/min [10.6, 21.1, 31.7, 42.3 and 84.5 US gal/min], pressure up to 350 bar [5076 psi].
- Pilot operated flow-amplifiers with amplification factors of 4, 5, 8, 10 or 20 for rated oil flows of 240 and 400 l/min [63.4 and 105.7 US gal/min], steering pressure up to 210 bar [3045 psi].
- Pilot operated steering valve with steering flow up to 100 l/min [26.4 US gal/min], steering pressure up to 250 bar [3625 psi] and with integrated priority valve for pump flow up to 120 l/min [31.7 US gal/min].

A wide range of Steering Components

For electrohydraulic steering systems Danfoss offers:

- Pilot operated steering valves (pilot operated by hydrostatic steering unit or by electrical signal) with steering flows up to 100 l/min [26.4 US gal/min], steering pressure up to 250 bar [3625 psi].
- Steering units with integrated electrical operated steering valve with steering flow up to 50 l/min [13.2 US gal/min], steering pressure up to 210 bar [3045 psi].

Characteristic features for steering units:

- Low steering torque: From 0.5 N•m to 3 N•m in normal steering situations
- Low noise level
- Low pressure drop
- Many types available: Open center Non-reaction, Open center Reaction, Power Beyond, Closed center Non-reaction, Load Sensing, Load Sensing Reaction
- One or more built-in valve functions: relief valve, shock valves, suction valves, non-return valve in P-line and in LS-line
- Optional port connections (according to ISO, SAE or DIN standards)

Characteristic features for electrohydraulic steering systems with OSPE and EHPS:

- Possibility of GPS, row sensor, variable steering ratio and joystick steering
- The possibility of manual steering even on very heavy vehicles
- EHPS: High steering pressure requiring smaller cylinders and flow
- EHPS: Low pilot pressure and flow giving extremely low noise in the cabin
- EHPS: Can be combined with Danfoss PVG 32 proportional valve

Conversion factors

1 N•m = [8.851 lbf•in]

1 N = [0.2248 lbf]

1 mm = [0.0394 in]

1 cm^3 = [0.061 in^3]

1 l = [0.264 US gal]

1 bar = [14.5 psi]

°F = [1.8°C + 32]

Survey of literature with technical data on Danfoss Steering Components

Detailed data on all Danfoss steering components and accessories can be found in our steering component catalogues, which is divided in to the following individual sub catalogues:

General information	Steering components
Technical data on mini steering units	OSPM
Technical data on open center, and closed center steering units	OSPB, OSPC, and OSPD
Technical data on load sensing steering units, priority valves and flow amplifiers	OSPB, OSPC, OSPF, OSPD, OSPL, OSPBX, OSPLX, OVPL, OLS and OSQ
Technical data on hydraulic and electrohydraulic pilot operated steering valves, electrical actuation modules and appropriate steering units.	EHPS, EHPS w. OLS 320, PVE for EHPS and OSPCX
Technical data on combined steering unit/electrohydraulic steering valves and steering wheel sensors	OSPE and SASA
Technical data on load sensing steering unit with amplification	OSPU

For technical information on individual variants, please contact the Danfoss Sales Organization.

General

General steering valve type OSPE

On tractors, combine harvesters, maize harvesters and other simulate vehicles there is often a need for electrically actuated steering to make automatic GPS controlled steering possible. Also manual steering with variable ratio is an often wanted feature to improve productivity and driver comfort.

For this purpose Danfoss has developed a combined steering unit and electro hydraulic steering valve named OSPE: **OSP** for normal manual steering wheel activated steering and E for electro hydraulic steering activated by electrical input signal either from GPS or vehicle controller or from steering wheel sensor (Danfoss type SASA) for variable steering ratio. In variable steering mode, the electro hydraulic valve part adds flow to the metered out flow from the steering unit part of the OSPE.

OSPE has build in safety function in form of cut off valve, which makes unintended steering from Electro hydraulic valve part impossible. So OSPE is the right steering element first of all to build up steering system with very high safety level and so to be able to fulfill legislations demands like e.g. demands in **EU Machinery Directive 2006/42/EC**

In cases where space do not allow room enough for OSPE, an ordinary OSP non-reaction steering unit combined the EH-Electro Hydraulic In-Line steering valve is an alternative. EH valves are offered with the same safety functions as OSPE. Please contact Danfoss sales organisation.

Versions

Overview

Steering valve OSPE and electrical actuation module PVE

Steering unit part		
Version	Spool/sleeve type	Gear set
OSPEC xxx LSRM	“C”-dynamic, LSRM, Load Sensing, Reaction	Single
OSPEF xxx LS	“F”-dynamic, LS, Non-Reaction	Single
OSPEDC xx/yyy LSRM	“C”-dynamic, LSRM, Load Sensing, Reaction	Dual
OSPEDF xx/yyy LS	“F”-dynamic, LS, Non-Reaction	Dual

EH-part of OSPE in combination with any OSPE	
Spool type	PVE actuator
Static	PVES, PVED CC, PVED CLS

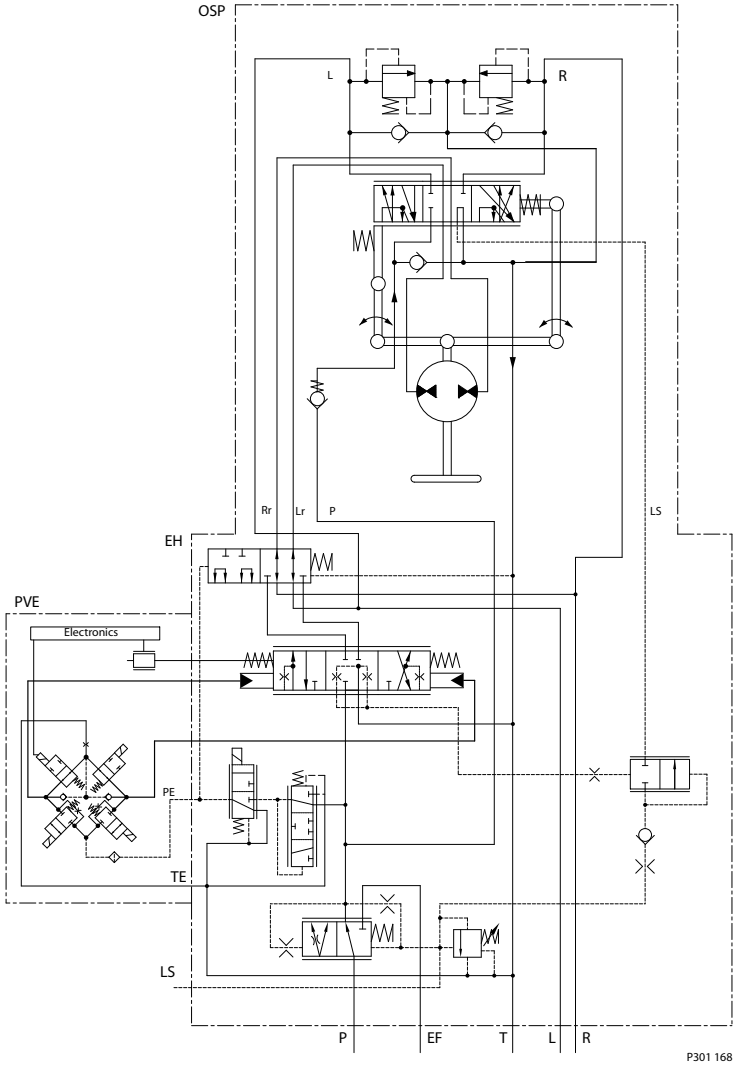
Priority valve in OSPE in combination with any OSPE	
Spool type	Note
Dynamic	If priority valve is present elsewhere in system, OSPE can be w.o. priority valve.

Versions

OSPEC LSRM:

This version is preferred for front wheel steered vehicles, like e.g. tractors, where self-alignment steering effect is desired. Reaction type steering resembles a car where the direction of travel will continue straight ahead when ever the steering wheel is not touched. The reaction concept in any OSPE steering units is based on Danfoss RM technology. The reaction effort is selectable by help of the solenoid valve for activating EH steering:

- Road mode: When EH steering is powered off, then OSPE behaves the same as a Reaction unit
- Field mode: When EH steering is powered on, then OSPE behaves the same as a Non-reaction unit



Versions

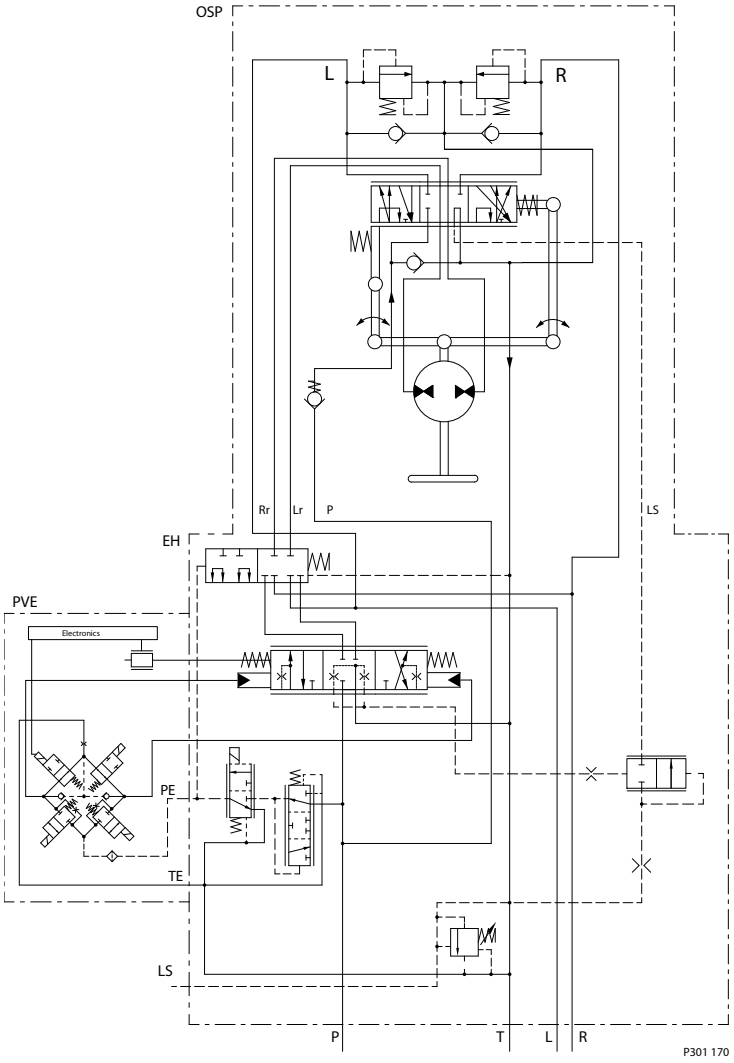
OSPEF LS

This version is preferred for rear wheel steered vehicles, like e.g. combines.

In both modes:

- Road mode: When EH steering is un powered
- Field mode: When EH steering is powered

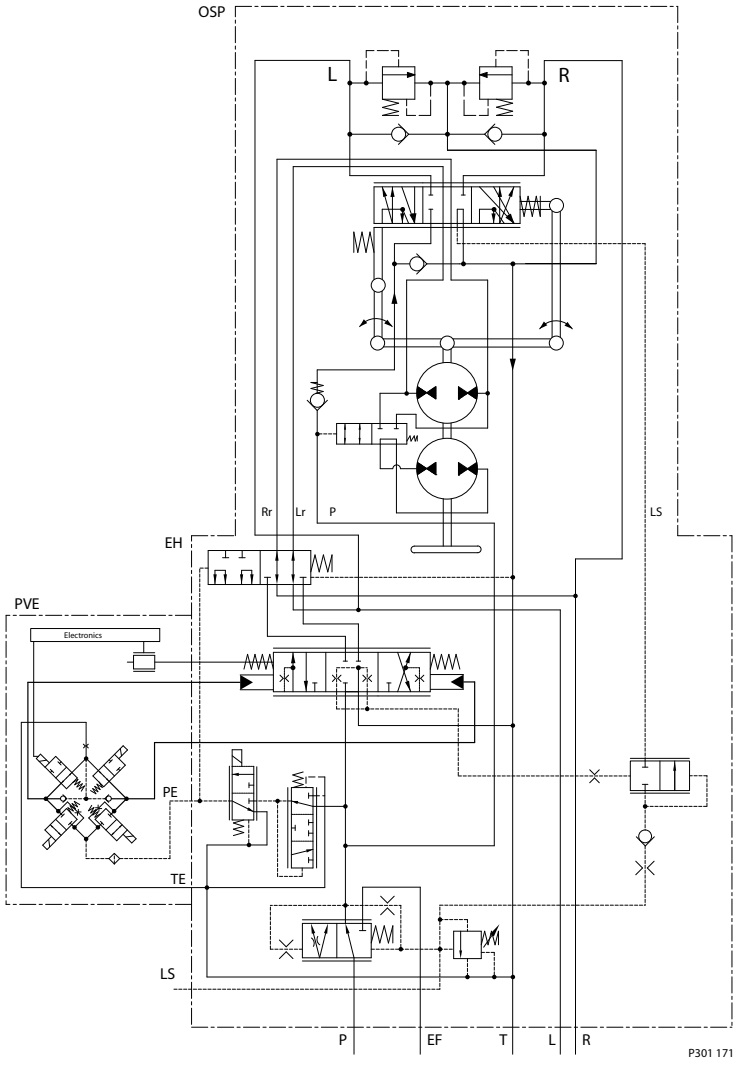
the steering unit part behaves as a Non-reaction steering unit. The “F”-spool type is preferred for steering systems where high level of negative steering forces may be present e.g. articulated steered vehicles.



Versions

OSPEDC LSRM

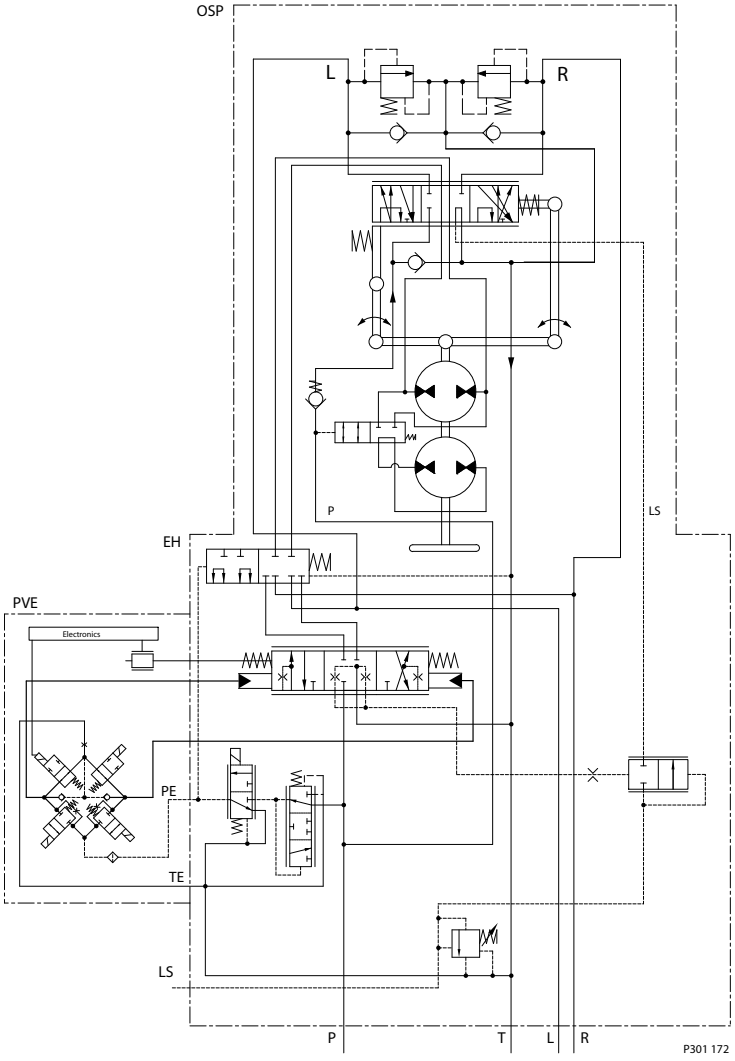
This version is preferred for front wheel steered vehicles, like e.g. tractors, where self-alignment steering effect is desired. Only difference compared to OSPEC LSRM is that “D” type has 2 gear wheel sets (rotary meters). Should the pump supply be lost, only one gear set is active for emergency steering. In normal steering situations both gear sets are active.



Versions

OSPEDF LS

This version is preferred for rear wheel steered and articulated vehicles. Only difference compared to OSPEF LS is that “D” type has 2 gear wheel sets (rotary meters). This version however is shown without priority valve.



Steering valve EHPS and electrical actuation PVE for EHPS

PVED-CL/CLS

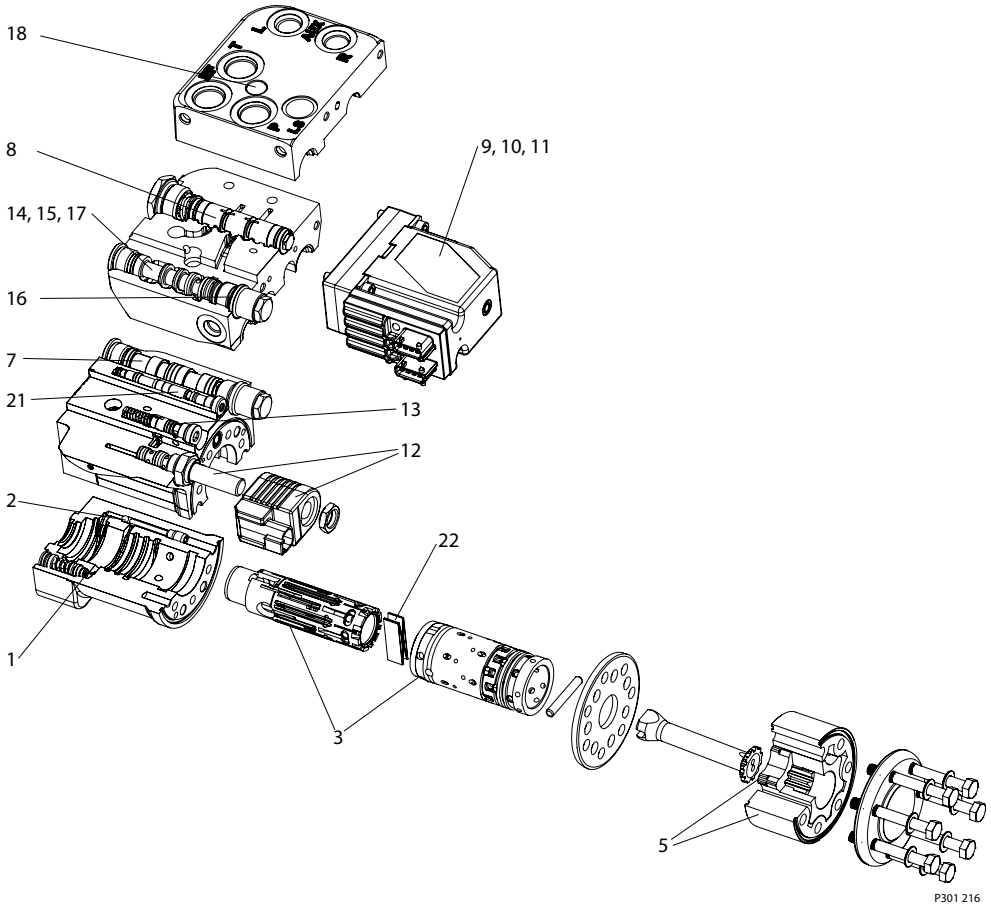
PVED-CL must not be promoted any longer. PVED-CL will be replaced by PVED-CLS by the end of 2014. Please contact Danfoss Sales Organization for further details.

OSPE with an electrical programmable module (PVED-CLS) the following steering features in electro hydraulic steer mode/field mode are possible:

- GPS-steering
- Row sensor/ camera steering
- Joy stick or mini st. wheel steering
- Variable steering ratio
- Speed depending steering ratio

Function

OSPE steering valve



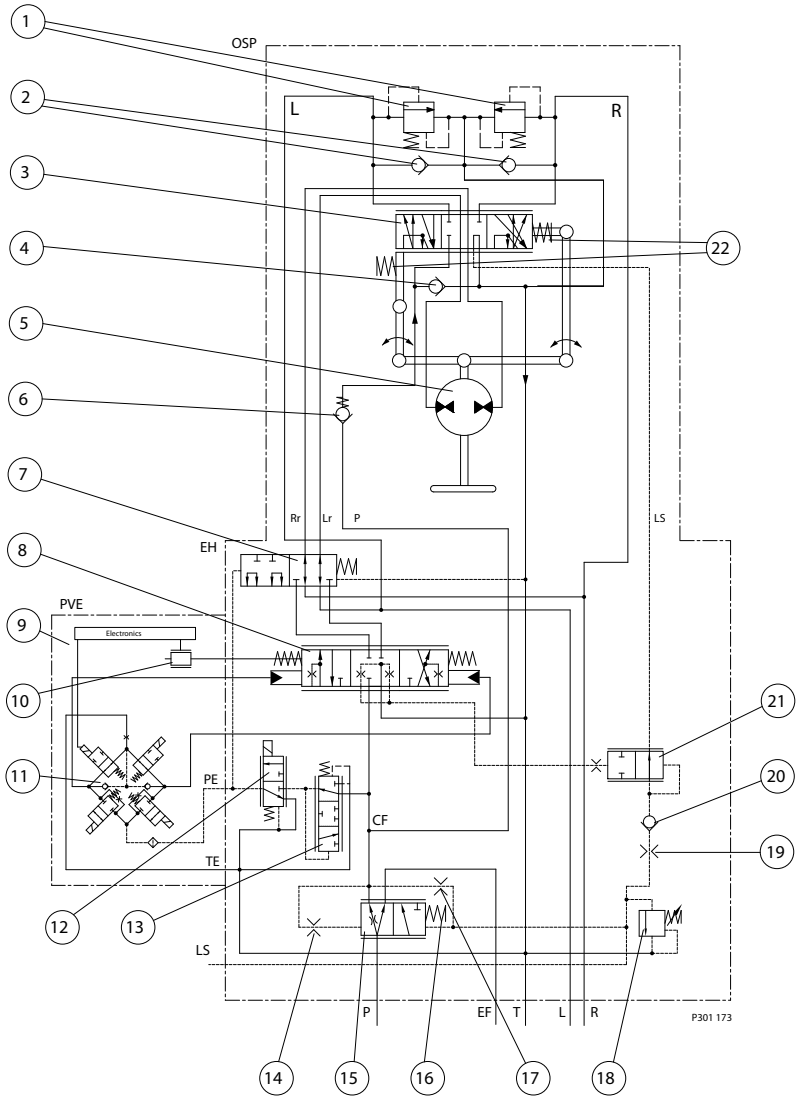
The OSPE steering valve includes the following main components

1	Shock valves	12	Control valve for mode select
2	Suction valves	13	Pilot reduction valve, 12 bar
3	Spool/sleeve set	14	PP damping orifice
5	Gear set	15	Priority valve spool
7	Mode select and EH cut off valve	16	Priority valve spring
8	EH directional valve	17	Dynamic orifice
9	PVE control unit	18	Pilot pressure relief valve
10	LVDT transducer	21	PVFC valve/LS resolver
11	Solenoid valve bridge	22	Neutral spring package for spool/sleeve

Function

OSPEC LSRM

Neutral position



1	Shock valves	12	Control valve for mode select
2	Suction valves	13	Pilot reduction valve, 12 bar
3	Spool/sleeve set	14	PP damping orifice
4	Emergency steering check valve	15	Priority valve spool
5	Gear set	16	Priority valve spring
6	P-check valve	17	Dynamic orifice
7	Mode select and EH cut off valve	18	Pilot pressure relief valve
8	EH directional valve	19	LS orifice
9	PVE control unit	20	LS check valve
10	LVDT transducer	21	PVFC valve/LS resolver
11	Solenoid valve bridge	22	Neutral spring package for spool/sleeve

When the engine is turned off, the priority valve spool (15) is pushed to the left by the spring (16).

The passage to the EF port is blocked and the passage to CF to the OSP spool/sleeve set (3) and to the EH directional valve spool (8) is open.

Function

When the engine is on and the steering unit OSP and EH is in neutral position, the CF pressure will rise to match the spring force in the priority valve, and the priority valve spool (15) will move to the right and the oil will pass from the pump across the integrated priority valve spool (15) and out through the EF port.

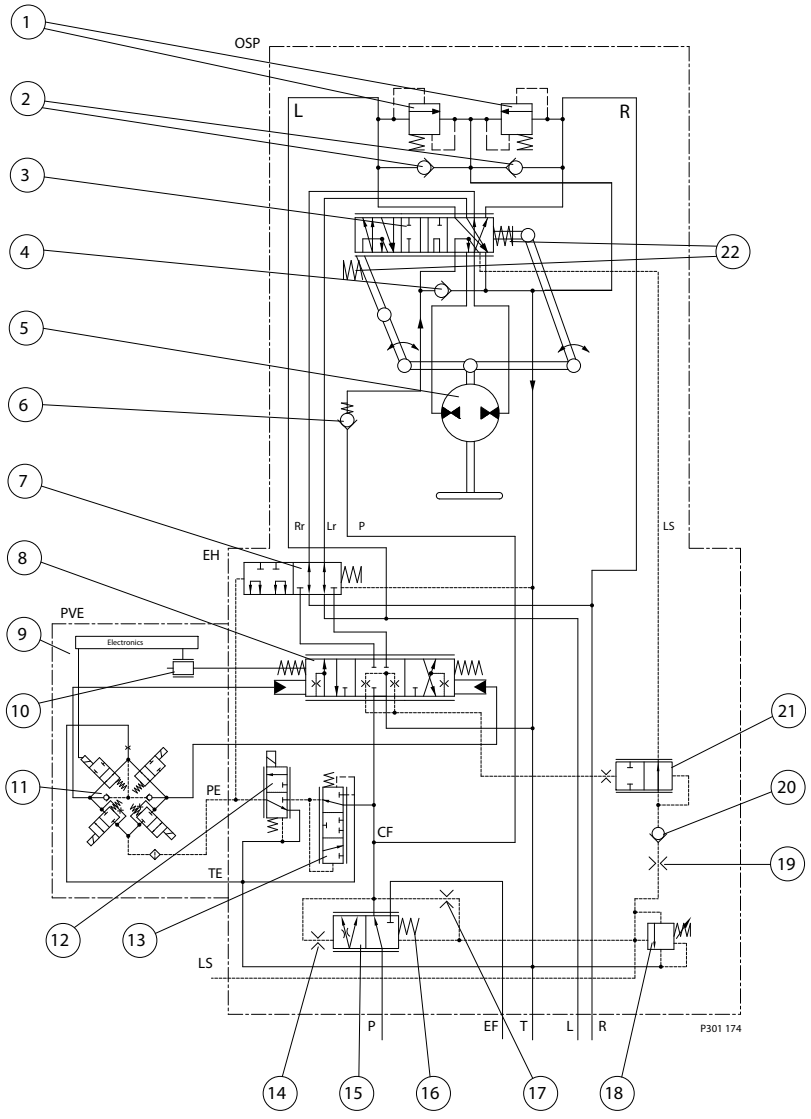
The priority valve is a “dynamic” type, meaning that a flow passes from CF through the Dynamic orifice (17) (integrated in spool 15) and into the LS line through the LS orifice (19), LS check valve (20), the PVFC valve (21) and into the spool/sleeve set (3). In neutral position this dynamic oil flow passes on to the tank.

When the steering unit is in neutral position and control valve (12) is deactivated, then the mode select/EH cut off valve (7) makes connection through the Reaction circuit, Lr and Rr. So if the steering wheel is untouched and a delta P is generated in the steering cylinder, oil will pass from L to R or R to L through the spool/sleeve set (3) and gear set (5) and the steering wheel will rotate until it is grabbed or delta P disappears. Only the force of the neutral spring package (22) has to be overcome to stop the rotation of the steering wheel and therefore stop the cylinder movement. The mode select/EH cut off valve (7) makes unintended EH steering impossible, if e.g. a false input signal comes to the PVE control unit (9), when the control valve (12) is deactivated, because L and R connections from EH directional valve spool (8) are blocked in (7).

If the control valve (12) is activated, then the mode select/EH cut off valve (7) blocks connection through the Reaction circuit. In this position there will be no reaction behavior even if there is build up delta P on the steering cylinder from forces on the steered wheels. So the steering unit behaves as a Non reaction OSP. In that situation (If the control valve (12) is activated) EH steering is possible.

Function

Steering right with steering wheel



1	Shock valves	12	Control valve for mode select
2	Suction valves	13	Pilot reduction valve, 12 bar
3	Spool/sleeve set	14	PP damping orifice
4	Emergency steering check valve	15	Priority valve spool
5	Gear set	16	Priority valve spring
6	P-check valve	17	Dynamic orifice
7	Mode select and EH cut off valve	18	Pilot pressure relief valve
8	EH directional valve	19	LS orifice
9	PVE control unit	20	LS check valve
10	LVDT transducer	21	PVFC valve/LS resolver
11	Solenoid valve bridge	22	Neutral spring package for spool/sleeve

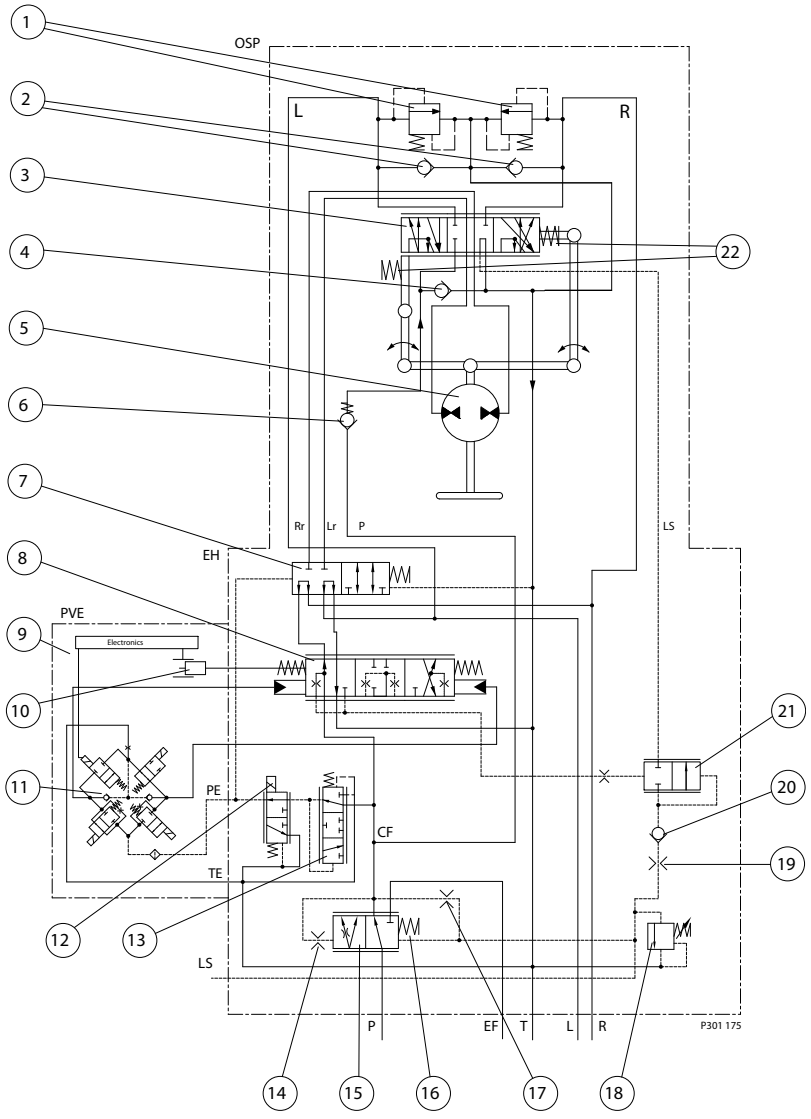
When steering with the steering wheel to the right, the spool of the spool/sleeve set (3) will rotate relative to the sleeve. So LS line will be connected to R-side. LS pressure will raise accordingly to steering pressure required and priority valve spool (15) will be pressed to the left and oil will stream through the internal CF side of the priority valve and on to the spool/sleeve set (3) through the gear set (5) and out through the R connection. In parallel the L side is opened through the spool/sleeve set (3) to tank (T). When steering up against cylinder end stop, pressure will raise in LS line according to setting of pilot

Function

pressure control valve (18). Check valve (20) avoids oil to stream backwards from servo side (R in this case) and over valve (18) to tank. So the valve (18) shall only open for the dynamic flow generated in the dynamic orifice (17) of priority valve part, independent if steering is done by the steering wheel (OSP part) or by the EH valve.

Function

Steering right with EH



1	Shock valves	12	Control valve for mode select
2	Suction valves	13	Pilot reduction valve, 12 bar
3	Spool/sleeve set	14	PP damping orifice
4	Emergency steering check valve	15	Priority valve spool
5	Gear set	16	Priority valve spring
6	P-check valve	17	Dynamic orifice
7	Mode select and EH cut off valve	18	Pilot pressure relief valve
8	EH directional valve	19	LS orifice
9	PVE control unit	20	LS check valve
10	LVDT transducer	21	PVFC valve/LS resolver
11	Solenoid valve bridge	22	Neutral spring package for spool/sleeve

Before it is possible to steer with the EH part of the OSPE, it is needed to power the control valve for mode select (12) for field mode. When this valve is powered, the pilot supply (12 bar) is lead from the pilot reduction valve (13) through the control valve (12) to the solenoid valve bridge (11) of the PVE control unit (9) and in parallel to the mode select and EH cut off valve (7). So the valve (7) makes connection from EH directional valve (8) to the cylinder ports, L and R. In the same shift, the valve (7)

Function

interrupts the reaction circuit, Lr and Rr, from the spool/sleeve set (3) to the cylinder ports, and the unit acts as a non-reaction OSP in this mode.

When an input signal is transmitted to the electrical connector of the PVE (9), in this example signal to steer to the right, the solenoid valve bridge (11) is activated and the EH directional valve spool (8) is moved to the right. So LS in the spool (8) will sense the needed steering pressure, and this is transmitted to the PVFC valve /LS resolver (21). So the valve (21) makes restrictions in the dynamic LS flow from dynamic orifice (17) of priority valve, and the LS pressure in the priority valve spool (15) will match the LS pressure required from the EH directional valve spool (8). Accordingly the position of the priority valve spool (15) will change to match the flow demand for EH-steering.

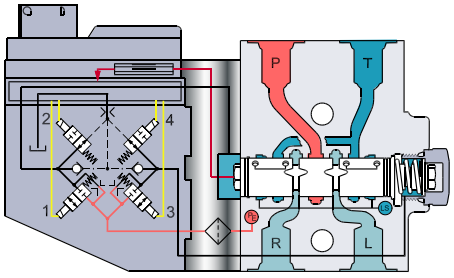
In case an external “watch dog” registers an unintended steering movement e.g. due to a false input signal to the PVE, the electrical power to the control valve for mode select (12) must be switched off. This must be controlled by the “watch dog”.

So valve 12 will dump pilot pressure to tank, mode select and EH cut off valve (7) will change position so that connection from EH directional valve spool (8) to cylinder ports will be blocked. Furthermore it will not be possible to activate the solenoid valve bridge (11) and the PVE will go into/stay in neutral position. In this way a true safe state is established.

The non-reaction circuit from the OSP part is always connected to L and R cylinder ports independent of position of mode select valve (7), and so OSP steering is always possible.

PVES and PVED-CLS, electrical actuation

The philosophy of Danfoss electro hydraulic actuation, type PVE, is integration of electronics, sensors and actuators into a single unit that interfaces directly to the OSPE steering valve body.



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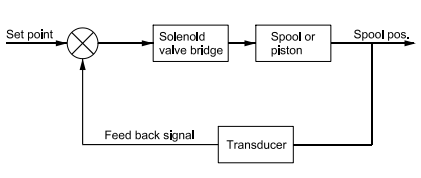
Closed loop control

All the proportional actuators feature an integrated feedback transducer that measures spool movement in relation to the input signal, and by means of a solenoid valve bridge, controls the direction, velocity and position of the directional spool of the valve. The integrated electronics compensate for flow forces on the spool, internal leakage, changes in oil viscosity, pilot pressure, etc. This results in lower hysteresis and better resolution. Furthermore the electronics enable built in safety like fault monitoring, directional indication and LED light indication.



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Principle

In principle the input signal (set-point signal) determines the level of pilot pressure which moves the main spool. The position of the directional spool is sensed in the LVDT transducer which generates an

Function

electric feed-back signal registred by the electronics. The variation between the set-point signal and feed-back signal actuates the solenoid valves. The solenoid valves are actuated so that hydraulic pilot pressure drives the directional spool into the correct position.

Inductive transducer, LVDT

(Linear Variable Differential Transformer). When the directional spool is moved, a voltage is induced proportional to the spool position. The use of LVDT gives contact-free monitoring of the directional spool position. This means an extra-long working life and no limitation as regards the type of hydraulic fluid used. In addition, LVDT gives precise position signal of high resolution.

Integrated pulse width modulation

Positioning of the directional spool in PVES is based on the pulse width modulation principle. As soon as the directional spool reaches the required position, modulation stops and the spool is locked in position.

Technical data

OSPE

The technical data for OSPE are typical measured results. For the hydraulic system a mineral based hydraulic oil with a viscosity of 21 mm^2/s [102 SUS] and a temperature of 50°C [122°F] was used.

Gear set	Single, range	100-500 cm^3/rev	[6.1-30.5 in^3/rev]
	Dual, range	60/120 – 125/440 cm^3/rev	[3.7/7.3 – 7.6/26.8 in^3/rev]
Max. pressure	Port P, EF	250 bar	[3625 psi]
	Port LS	210 bar	[3045 psi]
	Port L, R	280 bar	[4060 psi]
	Port T	25 bar	[362 psi]
Oil flow rated	Port P, EF	90 l/min	[23.8 US gal/min]
	Port L/R, steering wheel steering	50 l/min	[12.2 US gal/min]
	Port L/R, EH steering	12, 20, 30 or 40 l/min	[3.2, 5.3, 7.9 or 10.6 US gal/min]
Spool travel, EH directional spool		± 4 mm	[± 0.16 in]
Dead band, EH-directional spool, nominal		± 0.8 mm	[± 0.03 in]
Priority valve	Type	Dynamic	
	Spring force	7 bar, 10 bar optional	[100 psi, 145 psi optional]
	Nominal flow	90 l/min	[23.8 US gal/min]
Oil temperature	Recommended temperature	30 --> +60°C	[86 --> +140°F]
	Min. temperature	-30°C	[-22°F]
	Max. temperature	+90°C	[190°F]
Ambient temperature		-30 --> +60°C	[-22 --> +140°F]
Oil viscosity	Operating range	12-80 mm^2/sec	[66.0-370.3 SUS]
	Min. viscosity	10 mm^2/sec	[58.9 SUS]
	Max. viscosity	460 mm^2/sec	[2134 SUS]
Filtration	Max contamination (ISO 4406)	21/19/16	
Temperature difference between steering unit and other hydraulics	Max.	10°C	[50°F]

Weights

Weight of OSPE

Type	Weight	
	kg	[lb]
OSPE 100	12.7	[28.0]
OSPE 125	12.8	[28.2]
OSPE 140	12.9	[28.4]
OSPE 160	13.0	[28.7]
OSPE 185	13.1	[28.9]
OSPE 200	13.2	[29.1]

Technical data

Weight of OSPE (continued)

Type	Weight	
	kg	[lb]
OSPE 230	13.5	[29.8]
OSPE 250	13.4	[29.5]
OSPE 315	13.7	[30.2]
OSPE 400	14.1	[31.1]
OSPE 430	14.2	[31.3]
OSPE 500	14.5	[32.0]

Weight of OSPED

Type	Weight	
	kg	[lb]
OSPED 60/120	14.6	[32.2]
OSPED 60/220	15.2	[33.5]
OSPED 70/170	14.8	[32.6]
OSPED 70/320	15.5	[34.2]
OSPED 80/240	15.1	[33.1]
OSPED 80/395	15.8	[34.8]
OSPED 100/260	15.2	[33.5]
OSPED 100/300	15.4	[34.0]
OSPED 125/285	15.3	[33.7]
OSPED 125/440	16.0	[35.3]

PVES

		PVES	
Supply voltage U_{DC}	rated	11 V to 32 V	
	range	11 V to 32 V	
	max. ripple	5%	
Current consumption at rated voltage PVES		0.57 A @ 12 V	0.3 A @ 24 V
Signal voltage	neutral	0.5 x U_{DC}	
	CR-port ↔ CL-port	0.25 • U_{DC} to 0.75 • U_{DC}	
Signal current at rated voltage		0.25 mA to 0.70 mA	
Input impedance in relation to 0.5 • U_{DC}		12 KΩ	
Input capacitor		100 ηF	
Power consumption PVES		7 W	

Technical data

Supply voltage	Function		PVES Prop. super s
Disconnected by means of neutral switch	Reaction time from neutral position to max. spool travel	max.	0.230
		rated	0.150
		min.	0.120
Disconnected by means of neutral switch	Reaction time from max. spool travel to neutral position	max.	0.175
		rated	0.090
		min.	0.065
Constant voltage	Reaction time from neutral position to max. spool travel	max.	0.200
		rated	0.120
		min.	0.050
Constant voltage	Reaction time from max. spool travel to neutral position	max.	0.100
		rated	0.090
		min.	0.065

PVED-CLS

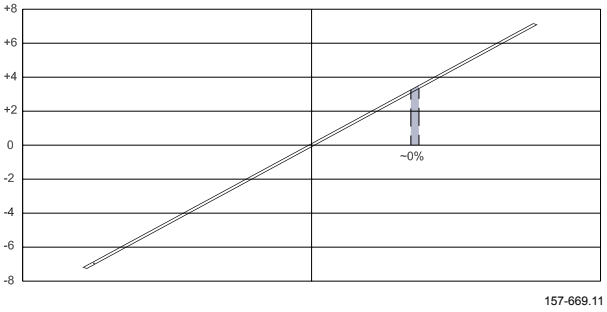
Information is under preparation.

Hysteresis, PVES and PVED-CLS

Hysteresis, PVES and PVED-CLS[1)]	rated	~ 0%

[1)] Hysteresis is indicated at rated voltage and f = 0.02 Hz for one cycle (one cycle = neutral -> full CL -> full CR -> neutral.

Spool travel



PVES and PVED-CLS

Oil consumption

Supply voltage	Function		PVES and PVED-CLS	
Without voltage	Pilot oil flow	neutral	0.3 l/min	[0.078 US gal/min]
With voltage	Pilot oil flow	locked	0.1 l/min	[0.026 US gal/min]
		continuous actuations	0.8 l/min	[0.211 US gal/min]

Technical data

Oil viscosity

Oil viscosity	range	12 - 75 mm^2/s	[65 - 347 SUS]
	min.	4 mm^2/s	[39 SUS]
	max.	460 mm^2/s	[2128 SUS]

Note: Max. start up viscosity 2500 mm^2/s

Oil temperature

Oil-temperature	Rec. range	30 - 60˚C	[86 -140˚F]
	min.	-30˚C	[-22˚F]
	max.	90˚C	[194˚F]

Filtering

Filtering in the hydraulic system	Max. allowed degree of contamination (ISO 4406, 1999 version): 23/19/16

Ambient temperature

Ambiant temperatur range Rec.	-30° → +60°C	[-22° → +140°F]

Pilot pressure

Pilot pressure (relative to T pressure)	nom.	13.5 bar	[196 psi]
	min.	10 bar	[145 psi]
	max.	15 bar]	[217 psi]

Enclosure and connector version

Version of connector	**AMP JPT connector**	**Deutsch® connector**
Grade of enclosure[1)]	IP 66	IP 67

[1)] According to the international standard IEC 529

In particulary exposed applications, protection in the form of screening is recommended.

Installation PVED-CLS

Information is under preparation.

Coil of control valve for mode select

Below technical data are valid for coil of control valve for mode select, when this coil is connected directly to the wiring of the application.

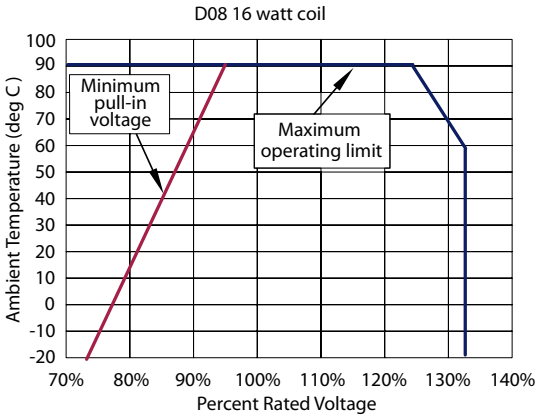
For OSPE with PVED-CLS the coil will be connected to the PVED-CLS, further technical data will be added.

Specifications

- Duty cycle rating: 100%
- Magnet wire insulation: Class H (180C)
- Ambient temperature: -30 to 60 ;°C [-22 to 140 °F]
- Diodes are available; contact your Danfoss representative.

Technical data

- Environmental protection: IP65
- Input voltage tolerance: ±10%
- All AC coils are internally rectified



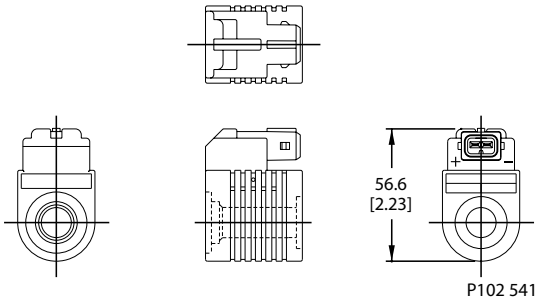
Electrical specifications

16 watt coils

Voltage (V)	Resistance (Ohms) ±5% @ 20 °C [72 °F]	Current draw (A) at 25 °C [77 °F]	Color
12 V_{DC}	9	1.33	Gray

Terminals

Amp Junior Timer Code AJ

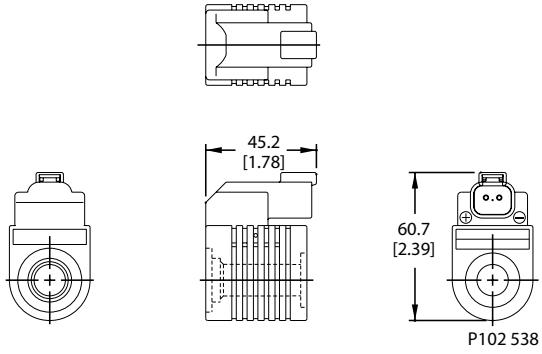


Part number

Voltage (V)	Power (W)	Part number
12 V_{DC}	16	D08-16-12D-AJ

Technical data

Deutsch® Code DE



Part number

Voltage (V)	Power (W)	Part number
12 V_{DC}	16	D08-16-12D-DE

Dimensioning

Dimensioning steering system with OSPE steering valve

The cylinder flow is determined from steering cylinder volume, number of revolutions on steering wheel from lock to lock and steering speed. Dimension of steering cylinder(s) can be based on formulas in “General, steering components” page 29-31.

Symbols:

V (l)	steering cylinder volume
i (rev)	number of steering wheel revolutions from lock to lock
Vvc (cm^3/rev.)	steering system displacement for steering cylinder
CQ (l/min)	nominal cylinder flow
Pems (bar)	emergency steering pressure
Tems (Nm)	emergency steering torque
Fe (N)	emergency steering wheel rim force
Swd (m)	steering wheel diameter
Vvs (cm^3/rev)	displacement, steering unit
PQ (l/min)	pilot flow
Qpm (l/min)	pump flow, minimum

Example:

Cylinder volume: V = 1.85 l [0.49 US gal]
Required number of steering wheel revolutions from lock to lock:
i = 4 – 5 revolutions

The required steering system displacement for steering cylinder is calculated from
*Vvc = V/i = (1.85*1000)/5 = 370 cm^3/rev [22.58 in^3/rev]*
*(1.85*1000)/4 = 463 cm^3/rev [28.25 in^3/rev]*

In this example we chose Vvc = 400 cm^3/rev [24.4 in^3/rev]
The nominal cylinder flow at 100 rpm speed on steering wheel.
*CQ = 400 * 100/1000 (cm^3/l) = 40 l/min [10.57 US gal/min]*In this case we try to use an “D” type steering unit to avoid emergency steering pump.

The “small” gear set, which is the only hydraulically active gear set in emergency steering mode is determined by the demand for emergency steering pressure, look in “General , steering components” page 28-29.

Emergency steering pressure, Pems, is calculated to be maximum
Pems = 40 bar [580 psi]

Maximum allowable steering torque Tems based on steering wheel rim force Fe=350 N and steering wheel diameter Swd = 0.381 m
*Tems = Fe * Swd/2 = 350 * 0.381/2 = 66.7 Nm [580 lbf•in]*

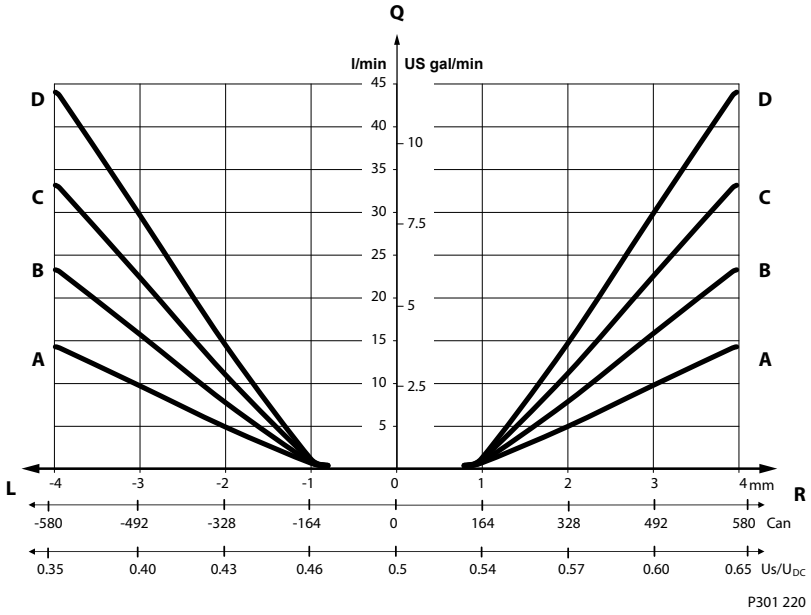
Emergency steering unit displacement can be chosen/calculated from the table lowest on page 29 in “General, steering components”.
The nearest displacement Vvs generating
minimum 40 bar [580 psi]at Tws = 66.7 N•m [580 lbf•in]
Vvs maximum = 80 cm^3/rev [4.88 in^3/rev]

So the closest combination on gear sets for this OSPED type will be: 80/395.
So the numbers of steering wheel revolutions from lock to lock will be.
i = V/Vvc = 1850/395 = 4.7 turns lock to lock.

Technical characteristics

EH-directional spools of OSPE

Cylinder flow characteristic for directional spools



A = valid for spools for nominal cylinder flow CQ = 12 l/min [3.17 US gal/min]

B = valid for spools for nominal cylinder flow CQ = 20 l/min [5.28 US gal/min]

C = valid for spools for nominal cylinder flow CQ = 30 l/min [7.97 US gal/min]

D = valid for spools for nominal cylinder flow CQ = 40 l/min [10.57 US gal/min]

The curves are valid for OSPE with internal priority valve w. 7 bar [100 psi] spring and 1.0 mm [0.039 in] dynamic orifice and @ 60 l/min [15.85 US gal/min] pump flow.

For OSPE without internal priority valve, the curves are valid in combination with external priority valve OLS 80, 152B8269 @ 60 l/min [15.85 US gal/min] pump flow.

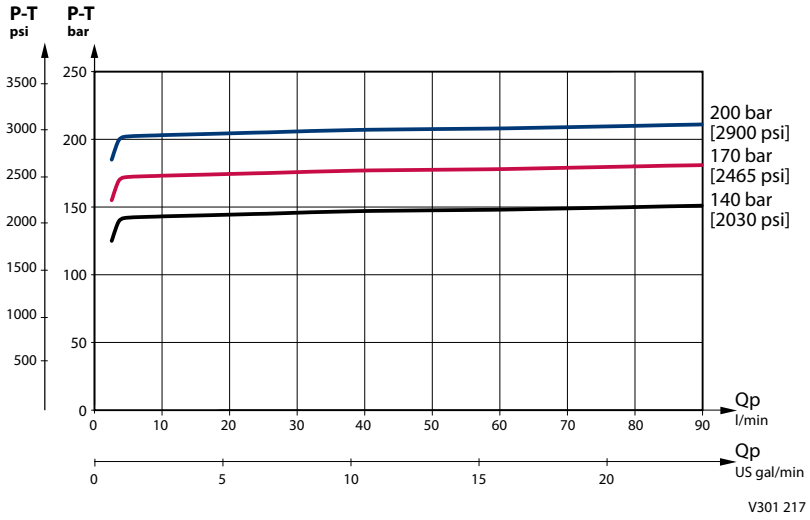
Pilot pressure relief valve: (P - T, Qp) characteristic

The pilot pressure relief valve protects the steering system against excessive pressure.

The pilot pressure relief valve works together with the priority valve in the OSPE to limit the maximum steering pressure P-T. The pilot pressure relief valve is set at an oil flow to the priority valve of 25 l/min [6.6 US gal/min].

Setting tolerance: rated value +10 bar [145 psi].

Technical characteristics

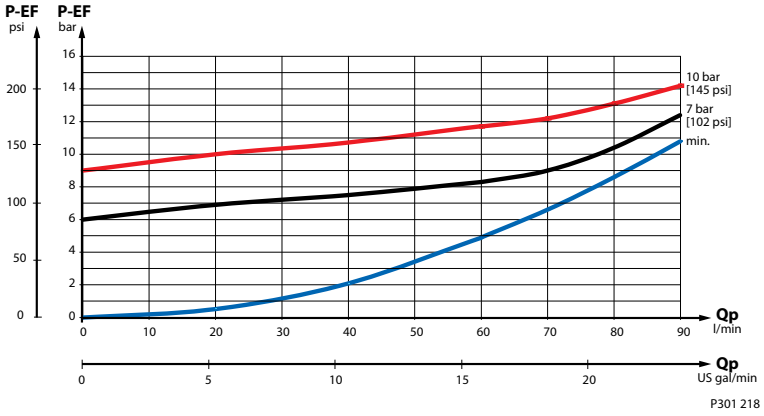


Pressure drop P-EF for Danfoss OSPE valve

This data comes from measurements on a representative sample of OSPE valves from production. Oil with viscosity of 21 mm^2/s at 50 °C was used during measuring. Measurement is made when the pressure on the LS connection is zero. The minimum curve applies when the pressure on the EF connection is higher than the actual control spring pressure.

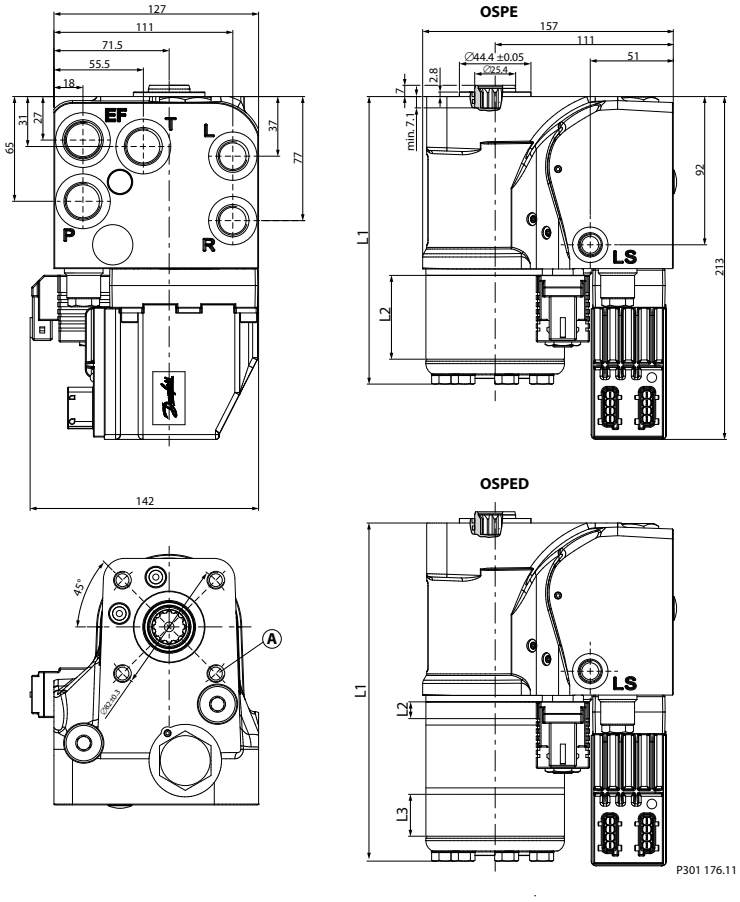
The curve for control spring pressure of 7 bar [100 psi] and 10 bar [145 psi] applies when pressure on the EF port is zero.

OSPE with priority valve spool



Dimensions

OSPE dimensions



Metric-port version (ISO 6149-1):

P, T, EF:	M22 x 1.5, 15 mm deep
L, R:	M18 x 1.5, 14.5 mm deep
LS:	M12 x 1.5, 11.5 mm deep
A:	4x M10 x 1.5, 16 mm deep

OSPE dimensions

Type	L_1		L_2	
	mm	[in]	mm	[in]
OSPE 100	140	[5.51]	13.0	[0.51]
OSPE 125	143	[5.63]	16.2	[0.64]
OSPE 140	146	[5.75]	18.6	[0.73]
OSPE 160	148	[5.83]	20.8	[0.82]
OSPE 185	151	[5.94]	24.0	[0.95]
OSPE 200	153	[6.02]	26.0	[1.02]
OSPE 230	162	[6.38]	35.1	[1.38]
OSPE 250	160	[6.30]	32.5	[1.28]

Dimensions

OSPE dimensions (continued)

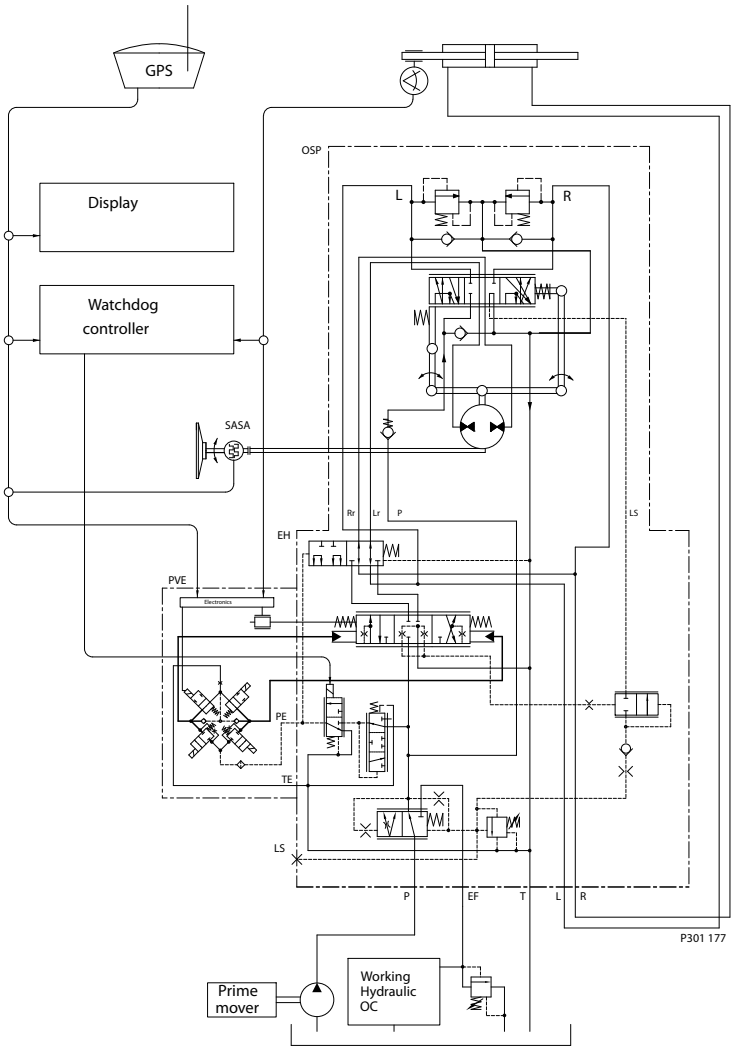
Type	L_1		L_2	
	mm	[in]	mm	[in]
OSPE 315	168	[6.61]	40.9	[1.61]
OSPE 400	179	[7.05]	52.0	[2.05]
OSPE 430	183	[7.20]	55.9	[2.20]
OSPE 500	192	[7.56]	65.0	[2.56]

OSPED dimensions

Type	L_1		L_2		L_3	
	mm	[in]	mm	[in]	mm	[in]
OSPED 60/120	193	[7.60]	9.1	[0.36]	9.1	[0.36]
OSPED 60/220	205	[8.07]	9.1	[0.36]	20.8	[2.39]
OSPED 70/170	197	[7.76]	9.1	[0.36]	13.0	[0.51]
OSPED 70/320	216	[8.50]	9.1	[0.36]	32.5	[1.28]
OSPED 80/240	206	[8.11]	10.4	[0.41]	20.8	[0.82]
OSPED 80/395	226	[8.90]	10.4	[0.41]	40.9	[1.61]
OSPED 100/260	209	[8.23]	13.0	[0.51]	20.8	[0.82]
OSPED 100/300	214	[8.43]	13.0	[0.51]	26.0	[1.02]
OSPED 125/285	212	[8.35]	16.2	[0.64]	20.8	[0.82]
OSPED 125/440	232	[9.13]	16.2	[0.64]	40.9	[1.61]

Hydraulic systems

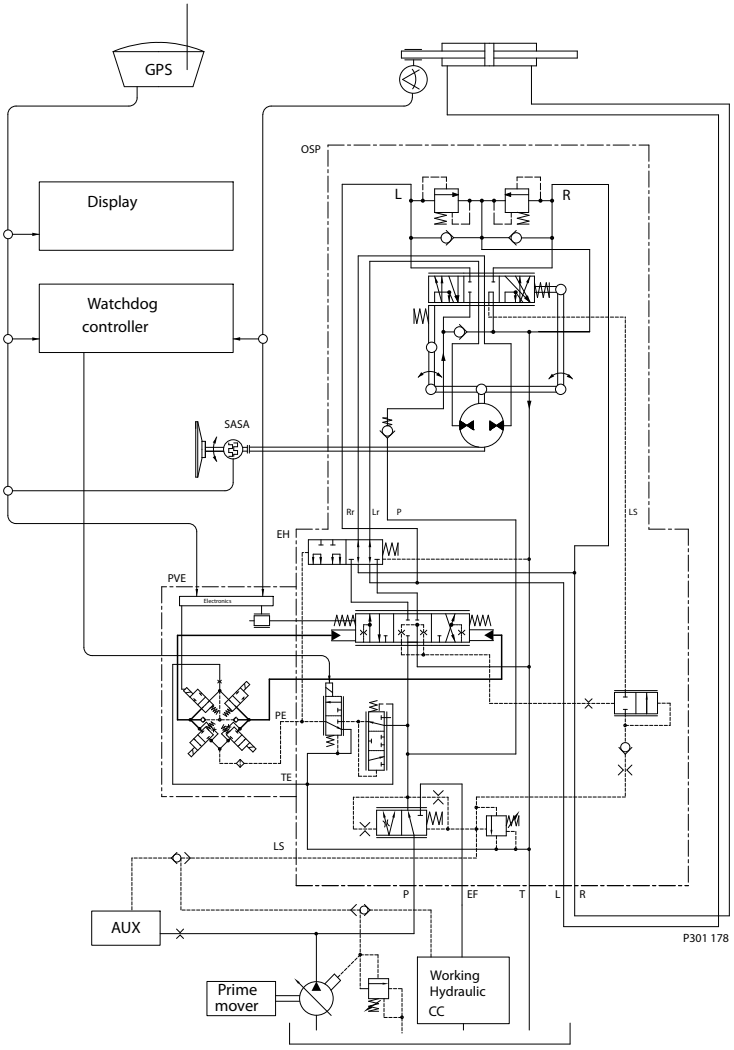
OSPE in a system with fixed gear pump and GPS steering



The pump, the OSPE priority valve part and the working hydraulics must be protected by a separate pressure relief valve.The vehicle controller/watch dog monitors input from the GPS, steering angle sensor (SASA) and signal from steering cylinder sensor. In case of unintended movement from the cylinder sensor, the watch dog shall remove power to the control valve for mode select/pilot dump, and in this way electro hydraulic actuation of steering cylinder is made impossible. The system turns into true safe mode.

Hydraulic systems

OSPE in a system with variable pump and GPS steering



The pump must have a built in pilot pressure relief valve to protect the OSPE, the priority valve part, the working hydraulics and the AUX function. AUX can be a brake system, which must have limited oil consumption to ensure steering capability in any case. Alternative pressure protection must be present in working and in AUX-hydraulic.

System safety

Emergency steering

The steering unit part of the OSPE acts like any other OSP steering units in case of no pump supply.

In such case the gear wheel set acts as a hand driven pump, and so muscular power will be converted from input torque and rotation on the steering wheel to hydraulic power in the form of pressure and flow out of the cylinder port to which side the steering is done. See *Dimensioning steering system with OSPE steering valve* on page 28 in this catalog and page 28 in “General, steering components” for calculating manual/emergency steering.

Please see promotional brochure 11059881 for further information.

OSPE and system safety PVES

Fault monitoring

A fault monitoring system is provided in all PVES modules. The system is available as passive fault monitoring type, which provides a warning signal only.

- Passive fault monitoring systems are triggered by three main events:
  1. Input signal monitoring

     The PVES input signal voltage is continuously monitored. The permissible range is between 15% and 85% of the supply voltage. Outside this range the section will switch into an active error state.
  2. Transducer supervision

     If one of the wires to the LVDT sensor is broken or short-circuited, the section will switch into an active error state.
  3. Supervision of the closed loop

     The actual position must always correspond to the demanded position (input signal). If the actual spool position is further than the demanded spool position (>12%,), the system detects an error and will switch into an active error state. On the other hand, a situation where the actual position is closer to neutral than that demanded will not cause an error state. This situation is considered “in control”.

     When an active error state occurs, the fault monitoring logic will be triggered:

Passive fault monitoring

- A delay of 250 ms before anything happens.
- The solenoid valve bridge will not be disabled but still control the main spool position.
- An alarm signal is sent out through the appropriate pin connection, no. 3.
- This state is not memorized. When the erroneous state disappears, the alarm signal will turn to passive again. However, the signal will always be active for a minimum of 100 ms when triggered.

To prevent the electronics from going into an undefined state, a general supervision of the power supply and the internal clock frequency is made. This function applies to PVES and will not activate fault monitoring:

System safety

1. High supply voltage

   The solenoid valves are disabled when the supply voltage exceeds 36 V, and the main spool will return/stay in neutral.
2. Low supply voltage:

   The solenoid valves are disabled when the supply voltage falls below 8.5 V, and the main spool will return/stay in neutral.
3. Internal clock

   The solenoid valves are disabled when the internal clock frequency fails, and the main spool will return/stay in neutral.

Safety considerations

On-road operation

Warning

The PVES or PVED-CLS shall be de-energized while driving on-road. It is the OEMs responsibility to establish the necessary means to inform and de-energize the PVE from the cabin when driving on public roads.

The Danfoss range of PVE actuators are single string designs with limited on board fault monitoring. Danfoss strongly recommends application of vehicle specific safety monitoring systems that will detect non-conforming steering and effectively disable electro-hydraulic actuators or issue appropriate warnings as the case may be. A minimum safety system should include a manual power switch to electrical power off electro-hydraulic actuators while driving on public roads.

For details, see:

- Technical information, PVE Series 4
- User Manual PVED-CL controller for Electro-Hydraulics Steering

or contact Danfoss Technical Support Team

Order specification

Variants and order specification

Specification table for Danfoss OSPE steering valve.

Part	Variants				
OSP	Gear set, cm^3/rev Single	100, 125, 140, 160, 185, 200, 230, 250, 315, 400, 430, 500			
	Dual, "D"-type	60/120, 60/185, 60/200, 60/220, 60/260, 60/290 70/140, 70/170, 70/195, 70/230, 70/270, 70/320, 70/385 80/160, 80/205, 80/240, 80/280, 80/395 100/200, 100/260, 100/300, 100/415 125/250, 125/325, 125/440			
	Spool/sleeve	"C"-dynamic,	LSRM, Load Sensing, Reaction		
		"F"-dynamic,	LS, Non-Reaction		
Actuation module	Type	PVES[2]	PVED CC	PVED CLS[3]	
	Connection	AMP (A)		Deutsch® (D)	
Coil for control valve/pilot dump	Connection	AMP (A)		Deutsch® (D)	
EH-directional spool	Cylinder flow, l/min	12	20	30	40
Priority valve	With spool, nominal flow, l/min	90			
	Spring force, bar	7		10	
	With out spool	No EF port present. P-flow determined by steering demand only			
Housing[1]	Thread	Metric			
Relief valve	Bar	100 - 210			
Shock valves	Bar	160 - 260			

[2] Only available with Deutsch® 6 pin connector

[3] Only available with Deutsch® 12 pin connector

[1] Housing, threads:

1) Housing threads

	P, T & EF	L & R	LS
Metric, ISO 6149-1	M 22 x 1.5 – O** + S**	M 18 x 1.5 – O* + S****	M 12 x 1.5 – O* + S**

* O-ring chamfer on port connection

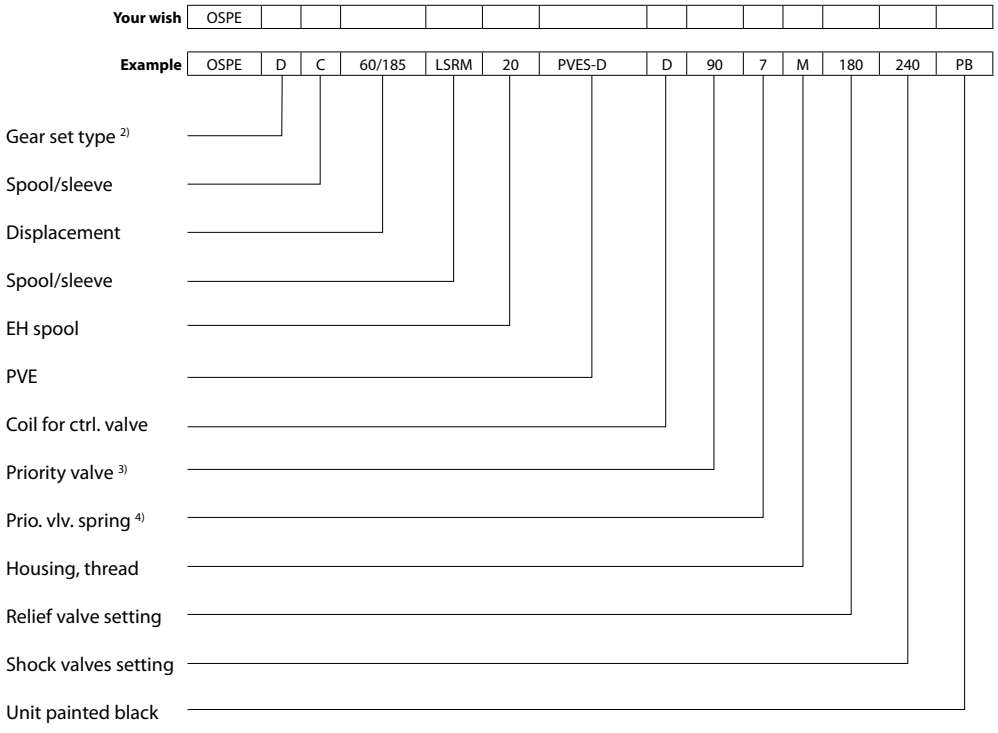
** Spot face around port connection

OSPEF w. displacement < 250 cc/rev. and integrated priority valve not to be used!

By experience we know the combination OSPEF with displacement < 250 cc/rev. and integrated priority may cause oscillations in steering system. Therefore do not specify such combinations. We recommend using OSPEC when displacement is smaller than 250 cc and if integrated priority valve is needed.

Specify your wish to the OSPE according to the destinations as in the example underneath the empty scheme:

Order specification



2) No designation for OSPE with single gear set

3) and 4) No designation for OSPE without priority valve

Code numbers

Code numbers for catalog versions with specifications:

Code numbers	Specifications according to above description format													
11081352	OSPE		C	100	LSRM	12	PVES-D	D			M	190	250	PB
11081366	OSPE		C	125	LSRM	12	PVES-D	D			M	190	250	PB
11081367	OSPE		C	160	LSRM	12	PVES-D	D			M	190	250	PB
11081369	OSPE		C	200	LSRM	20	PVES-D	D			M	190	250	PB
11081388	OSPE		C	250	LSRM	20	PVES-D	D			M	190	250	PB
11081389	OSPE		C	315	LSRM	30	PVES-D	D			M	190	250	PB
11081390	OSPE		C	400	LSRM	40	PVES-D	D			M	190	250	PB
11081391	OSPE		C	500	LSRM	40	PVES-D	D			M	190	250	PB

For weights, please see *Weights* on page 22.

Sensor type SASA

Sensor type SASA general

The SASA sensor detects the absolute position and speed of the steering wheel. The sensor can be used in electro-hydraulic steering systems using Danfoss EH or EHPS steering valves with programmable controller.

The use of SASA sensor is relevant e.g. for variable steering ratio and closed loop set-ups where steering wheel position and steering angle have to match.

SASA is based on a non-contact inductive principle giving a very high resolution.

The sensor features a robust design and resists e.g. electro-magnetic radiation.

The output is a CAN signal, which makes it easy to interface to advanced vehicle controllers.

The steering wheel shaft turns the rotor of the SASA sensor, and the sensor is simply mounted between steering unit and steering column. The shaft of the steering column must be 15 mm longer when using SASA sensor.

In cases where customers want to use the same steering column in applications with and without SASA sensors, Danfoss offers an adapter kit type SAK to built in between column and sensor.

The SASA sensor offers the following features:

- High resolution < 0.1°
- Output CAN signal
- High safety, “fail silent” concept
- *PLUS+1® Compliant*
- Flanged in between steering unit and column
- Compact design

Versions, code numbers and weights for SASA sensor

Code number	Type	Supply voltage	Termination resistor	Cable length	Connector	Weigth	
						kg	[lb]
11088656	CAN	9 - 32 V_{DC}	Non	500 mm	AMP code no. 2-967059-1	0.25	[0.55]
11099289	CAN	9 - 32 V_{DC}	Non	500 mm	*Deutsch®* DT04-4P-CE02	0.25	[0.55]

Code number and weight, SAK adapter kit

Code number	Weight	
	kg	[lb]
150Z6000	0.8	[1.76]

Sensor type SASA

CAN message protocol

Interface: CAN 2.0 B

Baud rate: 125 kBaud, 250 kBaud (default), 500 kBaud

SASA returns cyclic the following CAN message every 5, 10 (default) or 20 ms.

301 h	Data							
	0 Low byte	1 High byte	2	3 Low byte	4 High byte	5	6 Low byte	7 High byte
ID	Steering angle		Count	Steering angle change		Status	CRC-16	

Identifier: 301h (11 bit)

Steering angle: 12 bit word (0 – 4095) relative to a 0-index point.
0 = 0 degrees
4095 = 359,912 degrees
Overflow at 4095 for CW activation shall increment 0
Underflow at 0 for CCW activation shall decrement 4095

Count: byte (0-255)
Increments 1 for each message

Steering angle change: Difference between 2 transmitted position values in succession.
16 bit integer with 2's complementary encoding for negative values (-32768 to 32767).
-4095 = -359,912 degrees
0 = 0 degrees
4095 = 359,912 degrees

Status byte

7	6	5	4	3	2	1	0
-	-	-	-	-	-	-	Progamming mode

Programming mode: Normal state is 1
Response with a 0 when starting the programming sequence
(See the programming sequence described below under setup message)
CRC-16: The standard CRC16 polynomial is used (x^16+x^15+x^2+1)

Parameter setup

Setup message: sensor can be programmed as shown in the CAN setup message below.

0C0h	Data							
	0	1	2	3	4	5	6 Low byte	7 High byte
ID	Baud rate	Data rate	Set 0-index		Programming sequence		CRC-16	

Identifier: 0C0h (11 bit)

Baud rate: Byte 0 is set to
- 02h for 125 kBaud
- 03h for 250 kBaud (default)
- 04h for 500 kBaud

during the programming sequence

Data rate: Byte 1 is set to
- 02h for 5 ms
- 03h for 10 ms (default)
- 04h for 20 ms

during the programming sequence

Sensor type SASA

Set 0-index:	If byte 2 is set to AAh during the programming sequence, the actual angle will be stored as a reference value (0 degree) in persistent memory.
Programming sequence:	The following sequence is used when programming the sensor. The controller unit sends a setup message where byte 4 is set to AAh and byte 5 is set to 55h. The sensor answers with a 0 on the status byte (bit 0). The control unit then sends a setup message where byte 4 is set to 0Fh and byte 5 is set to F0h. The first and second message shall match. After receiving the last message the programming takes place in the sensor if the parameters are in the defined range, the timeout period has not been exceeded and the CRC-16 check is correct in both messages. After programming the status bit in the output message changes back from 0 to 1
Timeout period:	1s between first message from controller and response from sensor, and 1s between response from controller and second message from controller.
CRC-16:	The standard CRC16 polynomial is used (x^16+x^15+x^2+1)

Technical data

Mechanical

Input range:	Continuous 360° rotation
Rotor torque:	≤ 0.2 N•m
Expected life:	> 10 million cycles

Electrical

Supply voltage:	9 - 32 V_{DC}
Power consumption:	<1 W

Output

CAN V2.0B, (compatible to J1939)

Termination resistor:	120 ohm (optional)
Baud rate:	125, 250 or 500 kb/s
Angle:	12-bit word (0 - 4095) relative to a programmable 0-index point.
Resolution:	< 0.1°
Linearity:	±1.0%
Angle change:	16 bit integer with 2's complementary encoding for negative values (-32768 to 32767).

Safety function

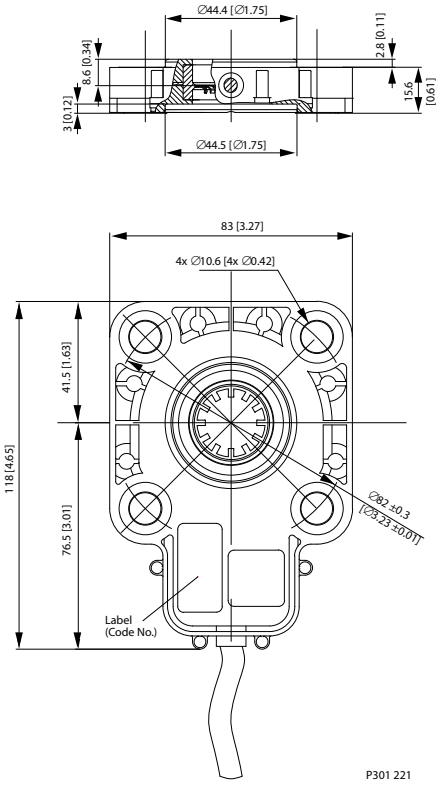
If a failure occurs the CAN-bus will "fail silent" (The CAN-bus driver will be disabled).

Environmental

Operating temperature:	-30° to 85°C [-22 to 185°F]
Storage temperature:	-40° to 105°C
Sealing:	IP65
EMI/RFI Rating:	100 V/m
Vibration:	Meets IEC 60068-2-64
Shock:	Meets IEC 60068-2-27 test Ea

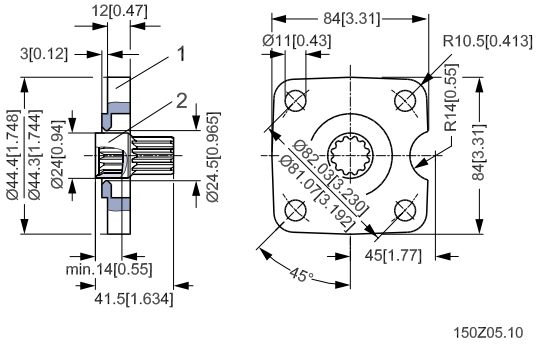
Sensor type SASA

Dimensions SASA sensor



SAK adapter kit

1. Flexible teeth, 12 pieces to interact with splines on steering column
2. Cable, 500 mm with connector. See “Code numbers” for type of connector



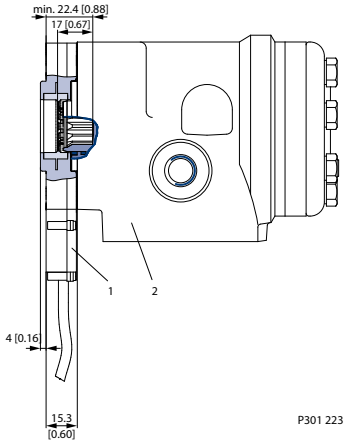
1. Distance plate
2. Shaft

Installation

SASA has to be mounted between steering column and steering unit (OSP) with 4 bolts max 30 N•m [265.5 lbf•in]. Shaft in column must be 15 mm [0.59 in] longer when using SASA.

Sensor type SASA

Assembly: SASA sensor and OSP steering unit



1. SASA sensor

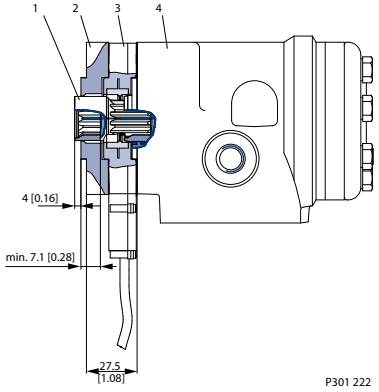
2. OSP steering unit

Caution

Make sure that the spline profile of the SASA sensor is aligned to the spline profile of the steering column shaft. A safe method of assembly is to place SASA sensor on the steering column spline shaft first – and not opposite! In case of using force, there is a risk of bending the spline profile of SASA sensor.

For use of original steering column, use adapter kit type SAK, see sketch below.

Assembly: SAK adapter kit, SASA sensor and OSP steering unit



1. Shaft of SAK adapter kit

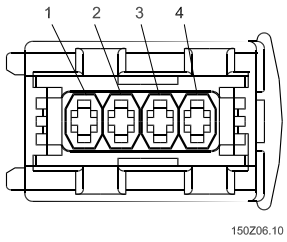
2. Distance plate of SAK adapter kit

3. SASA sensor

4. OSP steering unit

Sensor type SASA

Electric connection through cable mounted with an AMP Connector.



AMP type 2-967059-1

Pin 1 CAN-Low

Pin 2 +supply voltage

Pin 3 Gnd

Pin 4 CAN-High

Mating connector assembly

AMP type 2-965261-1

JPT contacts 2-962915-1

Wire sealing 828904-1

Recommended wiring practice

- Protect all wires from mechanical abuse.
- Use a wire gauge that is appropriate for the sensor electrical mating connector.
- Use wire with abrasion resistant insulation.
- Separate high current wires such as feeds to solenoids, lights, alternators, or fuel pumps from control wires. Recommended minimum separation is 300 mm [11.8 in].
- Run wires along the inside of or close to metal machine frame surfaces where possible. This simulates a shield which minimizes the effects of EMI/RFI radiation.
- Do not run wires near sharp metal corners. Run wires through grommets when rounding a corner.
- Provide strain relief for all wires.
- Avoid running wires near moving or vibrating components.
- Avoid long, unsupported wire spans.
- All sensors have dedicated wired power sources and ground returns. They should be used.
- Twist sensor lines about one turn every 100 mm [3.94 in].
- Use wire harness anchors that will allow wires to float with respect to the machine frame rather than rigid anchors.

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